Mediterranean Diet Inversely Associated With the Incidence of Metabolic Syndrome

The SUN prospective cohort

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There is some evidence of the beneficial role of food patterns and lifestyles on metabolic syndrome (1,2). The Mediterranean food pattern (MFP) has acquired an emerging role in cardiovascular epidemiology (3). It is characterized by a high consumption of fruits, vegetables, legumes, grains, moderate alcohol intake, a moderate-to-low consumption of dairy products and meats/meat products, and a high monounsaturated–to–saturated fat ratio. Although some cross-sectional studies have suggested that the MFP (or some of its components) may reduce the incidence of the metabolic syndrome (1,4), there are no prospective studies assessing this association.

Our aim was to prospectively assess the relationship between adherence to the MFP and the subsequent development of metabolic syndrome in the Seguimiento Universidad de Navarra (SUN) dynamic cohort, composed of Spanish university graduates followed up for 6 years (5).

RESEARCH DESIGN AND METHODS — The SUN Study uses methodology similar to that of large American cohorts (6), but recruitment is permanently open (it is designed as a dynamic cohort). Baseline assessment of participants consists of a self-administered questionnaire sent by postal mail, gathering information on lifestyle factors and including a 136-item validated food frequency questionnaire (7). Biennially mailed follow-up questionnaires are used to collect a wide variety of information about diet, lifestyle, and medical conditions (5).

Among the 18,000 graduates currently participating in the SUN cohort, 5,360 members were recruited more than 6 years ago and therefore were eligible for this assessment. Some (n = 1,627) are currently undergoing the process of completing their 6-year follow-up questionnaire (Q6). Only 236 other participants can be definitively classified as lost to follow-up because they have not returned their Q6 after five consecutive mailings. The rest of the participants (n = 3,497) returned their Q6 and were successfully retained.

Participants were excluded if at baseline they had implausible values for total energy intake, had BMI >30 kg/m^2 or reported risk factors (diabetes, hypertension, hypercholesterolemia, or hypertriglyceridemia), or met the criteria for metabolic syndrome. After exclusions, 2,563 participants initially free of metabolic syndrome or risk factors were available for analyses.

A previously applied score (8,9) was used to asses the degree of adherence to the MFP. Beneficial components were monounsaturated–to–saturated fat ratio, legumes, cereals, vegetables, fruits, fish, and alcohol. Subjects whose consumption was at or above the sex-specific median were assigned 1 point. For alcohol, the consumption of 5–25 g/day (women) and 10–50 g/day (men) qualified subjects to receive 1 point. Meats (or meat products) and dairy products were assessed negatively. Individuals whose consumption was below the sex-specific median were assigned 1 point. Therefore, the total score of adherence to the MFP had a potential range from 0 to 9 points. Metabolic syndrome was defined according to the International Diabetes Federation criteria (10).

In the Q6, self-reported information about these criteria was collected (waist circumference [cm], blood pressure [mmHg], triglycerides [mg/dl], HDL cholesterol [mg/dl], and plasma glucose [mg/dl]). Waist circumference was measured in a horizontal plane, midway between the inferior margin of the ribs and the superior border of the iliac crest (11). All participants were sent a tape measure with the Q6, and an explanation of how to measure their waist. If BMI was >30 kg/m^2, central obesity was assumed and waist circumference not taken into account.

Nonconditional logistic regression was used to assess the association between baseline adherence to the MFP and the cumulative incidence of metabolic syndrome during follow-up after adjusting for age, sex, smoking, physical activity, and total energy intake.

RESULTS — Median follow-up time was 74 months. Adherence to the MFP was higher among women, older subjects, ex-smokers, and more physically active participants. Participants with higher baseline adherence to the MFP exhibited lower levels of all risk factors after 6 years' follow-up except plasma glucose. HDL levels were higher among participants who better adhered to the MFP. However, we found significant differences only re-

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Abbreviations: MFP, Mediterranean food pattern; Q6, 6-year follow-up questionnaire.

A table elsewhere in this issue shows conventional and Système International (SI) units and conversion factors for many substances.

Table 1—*Baseline adherence to the MFP* and risk (cumulative incidence) of the metabolic syndrome after 6 years' follow-up*

	MFP score			
	0–2	3–5	6–9	*P* for trend
n	535	1,523	505	
Cumulative incidence of metabolic syndrome (%)†	2.6	2.5	0.8	0.003
Crude OR (95% CI)	1 (ref.)	0.95 (0.55–1.77)	0.30 (0.10–0.91)	0.134
Age- and sex-adjusted OR (95% CI)	1 (ref.)	0.76 (0.40–1.45)	0.18 (0.06–0.56)	0.006
Multivariate-adjusted OR (95% CI)‡	1 (ref.)	0.80 (0.42–1.54)	0.20 (0.06–0.63)	0.013
6-year follow-up levels of each risk factor§				
Waist circumference (cm)	82.5 ± 12	82.2 ± 12	82.0 ± 12	0.038¶
Systolic blood pressure (mmHg)	112.5 ± 14	112.5 ± 13	113.3 ± 13	0.648¶
Diastolic blood pressure (mmHg)	68.9 ± 11	68.8 ± 10	69.8 ± 10	0.664¶
Plasma glucose (mg/dl)	86.1 ± 11	85.8 ± 11	87.3 ± 17	0.524¶
HDL cholesterol (mg/dl)	63.8 ± 15	66.1 ± 19	64.1 ± 19	0.087¶
Triglycerides (mg/dl)	80.0 ± 38	81.2 ± 47	78.0 ± 40	0.116¶

Data are means ± SD unless otherwise indicated. *Trichopoulou's MFP score; †International Diabetes Federation criteria; ‡logistic regression adjusted for age, sex, physical activity (MET h/week), smoking (never, former, current), and total energy intake (kcal/day); §Mean values adjusted for age and sex; ¶Adjusted for age and sex (ANCOVA).

garding waist circumference and marginally significant differences for HDL. Subjects with the highest adherence to the MFP had lower cumulative incidence of the metabolic syndrome than those with the lowest adherence. This difference also persisted when we adjusted for age, sex, physical activity, smoking, and total energy intake (Table 1).

CONCLUSIONS — This is the first prospective cohort study that has evidenced an inverse relationship between adherence to an MFP and the cumulative incidence of the metabolic syndrome. Our results are consistent with previous findings (12). Some studies have also reported inverse associations between adherence to MFP and obesity (13–15), diabetes, insulin resistance (16,17), or hypertension (18,19). However, most of these studies were cross-sectional, and only two longitudinal prospective studies are available for the assessment of the relationship of MFP with obesity—not with the metabolic syndrome (13,14). Therefore, there is scarcity of data and no complete consistency (1).

Residual confounding because of a healthier lifestyle associated with higher adherence to the MFP might be a limitation of our study. However, after adjusting for lifestyle, changes were minimal, and the multivariate-adjusted results were too striking to be explained by residual confounding.

Other potential limitations of our study are related to the self-reported information. However, there is evidence indicating that self-reported information on hypertension is valid for epidemiologic studies (20), especially among highly educated populations (21). Moreover, we have previously validated the self-reported diagnosis of hypertension (22), weight (23), and physical activity (24) in subsamples of our cohort. Furthermore, >45% of our participants were health professionals. As a consequence, their self-reported information is likely to be of better quality than that of other studies based on self-report (25).

The prospective design or our study implies that information about risk factors for the metabolic syndrome, food habits, and lifestyles was collected before the diagnosis of the disease, thus avoiding a reverse causation bias. Another strength is that the food frequency questionnaire was previously validated in Spain (7). In summary, our findings add new information about the role of MFP for the prevention of the metabolic syndrome.

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